FY96

AIR VEHICLES

TECHNOLOGY AREA PLAN

HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE & TECHNOLOGY
WRIGHT PATTERSON AFB, OH

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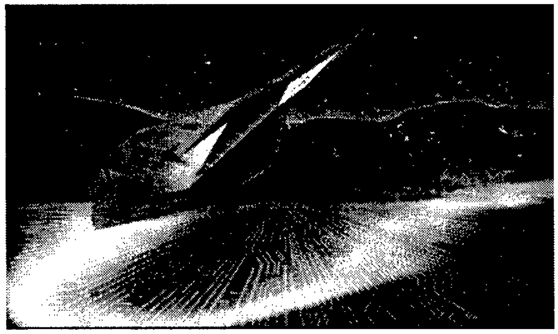
AIR VEHICLES



VISIONS AND OPPORTUNITIES

Prelude

Air Vehicles and their technologies have been a key to U.S. success in resolving conflicts throughout the 20th century. The recent conflict in the Persian Gulf reinforces this conclusion. In that conflict, conventional and low observable aircraft were used to rapidly soften up defenses, ruin command and control links, establish air superiority and virtually destroy the morale of the enemy prior to a ground battle. Superior air vehicles will continue to dominate modern warfare. The USAF, to maintain clearly superior aircraft vehicles and design capability, is focusing Science and Technology (S&T) investments on the development of highly affordable air vehicles while retaining their capabilities to win the conflicts of the future.

Wright Laboratory's Flight Dynamics Directorate (FI) has led innovative design concepts such as Fly-by-Wire Flight Control Systems, Aeroelastically Tailored Wings, Forward Swept Wings, Winglets, Thrust Vectoring Nozzles, Pneumatic Vortex Flow Control and other technologies. FI provided the nation with the first reradiative hypersonic flight test results in the ASSET Program, and developed the X-24B that provided the first high cross range, high lift/drag lifting reentry aircraft. FI technologies are the heart of every Air Force weapon system in today's operational inventory, as well as those systems in development. FI continues to expand the aircraft design envelope in all areas, including high temperature (4000°F) flight and high angles-of-attack (120°), to provide effective, superior aircraft vehicles.

To meet DoD and USAF needs, FI must continue to improve the efficiency of technology development, rank technology development programs, and focus on the development of the most beneficial, affordable, flexible and effective technologies to support the superior air vehicles of the future.

Vision

The FI vision is to fundamentally expand aircraft design and performance through revolutionary advancements in S&T. Our objective is to achieve affordable, extremely lethal and highly survivable systems that can serve interservice needs. By stressing flexibility and robustness, economies of scale can be realized to maintain innovation and creativity, despite the downturn in funding.

These air vehicles will demonstrate increased range and payload, increased precision strike, improved deployability, and highly improved battle damage tolerance. The FI challenge is to develop technologies that enable future, affordable systems to contain 70% to 80% common components within aircraft class. These technologies must be modular, allowing affordable and rapid reconfiguration to meet new requirements. FI will also work, in partnership through Project Reliance with the Naval Air Warfare Center, to develop multidisciplinary tools, methods, components

and subsystems at the component level, then integrate to the subsystem level until optimum system-level solutions are achieved.

Principal Planning Strategy

The Air Vehicles research and development plan is embodied in a set of Air Force goals developed jointly with Director, Defense Research and Engineering (DDR&E), the Navy, NASA, and the air vehicle design industry. These goals, reported in the Fixed Wing Vehicle Technology Development Approach (TDA), serve to describe the Flight Vehicle program as depicted in the DoD Defense Technology Plan. In this plan, five families of vehicles are identified: Fighter/Attack, Airlift/Patrol, SOF, Bomber, and Fast Response (Global). The goals address the performance, affordability and warfighter requirements over the 5-, 10-, and 15-year technology developmental time periods.

Opportunities

National goals and priorities for S&T are now defined and coordinated by DoD, NASA, and industry through the Air Force Technology Master Process (TMP) and the DoD Technology Area Plan (DTAP). This unified, focused approach creates a tremendous opportunity for aircraft technology development across DoD and NASA. Goals within the DTAP have been set and programs developed to solve fundamental technical barriers leading to affordable future aircraft. To emphasize achievement of these goals, the Air Vehicles Technology Area is fully aligned with the Air Force TMP and the DoD Air and Space Vehicles TAP.

Since conventional technology integration is a major cost driver in any new system, the Air Vehicle S&T program now incorporates an initiative in "integration technology" at the air vehicle subarea level. Methods to identify and analyze potential benefits of integrated technology are immature, but are beginning to emerge. Tools are also being developed to evaluate the value of technology programs with respect to operational payoffs and their ability to resolve identified warfighter deficiencies. Additionally, the air vehicle community as a whole must become more integrated. As R&D tools, processes and methods are matured, a combined set of developmental technologies can be identified which meet operational needs and deficiencies. Pursuing these opportunities to transfer technology will maintain the superiority of air vehicles, enhancing U.S. global reach and global power.

Summary

Air vehicles technology spans multiple technical disciplines to provide the Air Force and our nation with innovative solutions to both near- and far-term defense needs. Our scientists and researchers work in Integrated Product Teams (IPTs) that design, develop and provide optimum air combat capabilities. The IPTs, the TMP and the Mission Area Plans (MAPs), generated in coordination with the warfighter communities, ensure the emphasis of Research Development Test & Evaluation (RDT&E) is focused on the areas of greatest need. Affordability is paramount and is given utmost consideration in all phases of RDT&E within the Air Vehicles Technology Area.

During a time of declining budgets and resources, we are challenged to maintain and provide critical technologies, ensuring the nation's superior defense capabilities. We developed a strategic plan for Air Vehicles RDT&E to ensure we can maintain our leadership role, and to build a foundation for continuing excellence into the future.

This plan has been reviewed by all Air Force laboratory commanders/directors and reflects integrated Air Force technology planning. We request Air Force Acquisition Executive approval of the plan.

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INTRODUCTION

Background

The Air Vehicles Technology Area, highlighted in Figure I.1, is part of the Air Force Science and Technology (S&T) program. The Air Vehicles Technology Area Plan (TAP) identifies how advanced aircraft technology is developed to address solutions to user needs by using the Technology Master Process (TMP) and the Mission Area Plans (MAPs) adopted by HQ AFMC and the user community.

All Air Force aircraft in service today incorporate design criteria and subsystem designs that were developed and validated in the Air Vehicles Technology Area. Recent successful accomplishments include:

- Accepted the baseline F-16 Variable-Stability In-Flight Simulator Test Aircraft (VISTA) as the Air Force simulation and research testbed, leading to reduced aircraft development costs.
- Evaluated within-visual-range air-to-air combat effectiveness with the Multi-Axis Thrust Vectoring (MATV) aircraft. Validated substantial advantages of thrust vectoring in close-in aerial combat.
- Completed large-scale wind tunnel tests to validate innovative high lift devices and advanced high angle-of-attack (AOA) control effectors for highly maneuverable, low observable fighters.
- Completed a detailed design of a future center fuselage using superplastically-formed titanium to demonstrate unitized construction and low-cost tooling. This could significantly reduce aircraft acquisition costs.
- Designed a flight control algorithm to reduce the effects of aircraft battle damage.
- Demonstrated the feasibility of artificial terrain imaging on helmet displays. Terrain imaging technology will lead to improved all-weather aircraft operational capability.
- Completed Halon replacement candidate agent screening and down-selected to one agent, in compliance with Congressional direction.

These accomplishments are directly tied to warfighter needs through the Technology Planning Integrated Product Team (TPIPT) and the Mission Area Plans (MAPs) process. The users and their specific needs are outlined within our Thrust writeups.

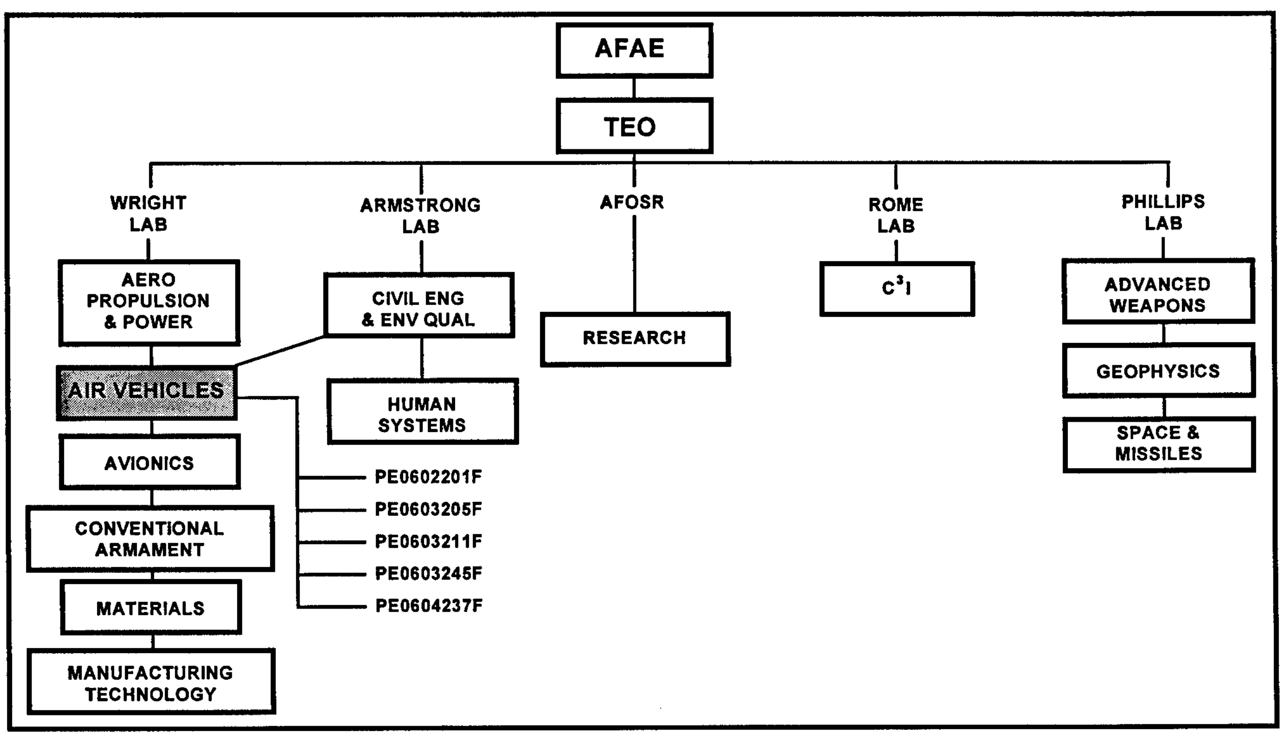


Figure I.1: Air Force S&T Program Structure

Air Vehicles technology users include the Aeronautical Systems Center (ASC), which manages the development and fielding of new aircraft and armament systems; Air Force Materiel Command (AFMC) and MAJCOMs, which develop, process, use, maintain and upgrade the existing aircraft fleet from "cradle to grave"; the aerospace industry, which develops, designs and manufactures military and commercial aerospace vehicle systems; and the Army, Navy, Marines, Coast Guard and Federal Aviation Administration (FAA), which rely on the Air Force for transition of Fixed Wing Air Vehicles technologies. The Air Vehicles Technology Area is the Tri-Service Lead for Fixed Wing Aircraft in Integration Technology, Aeromechanics, Structures, Flight Control, Advanced Cockpits and Vehicle Subsystems technologies. These technologies are mirrored in the Air Vehicles Thrust titles shown in Table I.1.

Table I.1: Major Technology Thrusts
1. INTEGRATION TECHNOLOGY
2. AEROMECHANICS
3. STRUCTURES
4. FLIGHT CONTROL
5. ADVANCED COCKPITS
6. VEHICLE SUBSYSTEMS

Air Vehicles S&T Funding

The funding to achieve the required Air Vehicles research is shown in Figure I.2, and reflects the Air Vehicles technology area share (7.3% in FY96) of the AF S&T budget. All funding is based on the President's FY96 Budget Request and is subject to change based on possible congressional action.

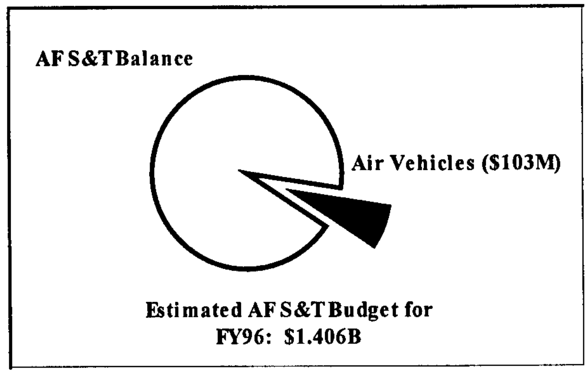


Figure I.2: Air Vehicles S&T $ vs Air Force S&T $

The Air Vehicles Thrust Areas funding breakdown is shown in Figure I.3.

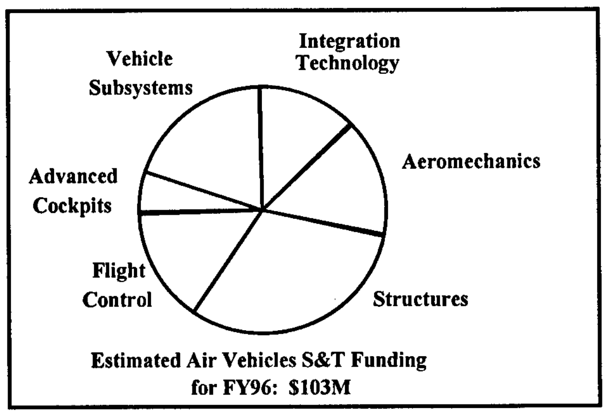


Figure I.3: Major Technology Area $

Relationship to Other Technology Areas

Air Vehicles Thrusts have relationships with our allies through Data/Information Exchange Agreements (DEAs/IEAs), and Memoranda of Understandings/Agreements (MOUs/MOAs). We have over 30 DEAs/IEAs with foreign countries to conduct research and development in basic technologies such as computational fluid dynamics, airframe weapons integration, aerothermodynamics optimization, aeroelasticity analysis methods, life prediction techniques for high-temperature structures, high AOA flight stability and control, flight control techniques, structural integrity, robust coatings and epoxy transparency repair, among others.

We have MOUs with the Air Force, Army, Navy, and NASA in subsystems and display technologies research, as well as working relationships with the Advanced Research Projects Agency (ARPA) on the congressionally directed High Definition Systems program. Specifically, we have an MOU between the Navy and the Air Force to conduct full-scale aircraft structural testing for the Navy. This joint effort will save the Navy the cost of moving its existing full-scale facility to Patuxent River, MD, along with the current plan to relocate the Naval Air Warfare Center, Aircraft Division, Warminster, PA. We also sponsor a program between the Air Force, Navy and NASA in the area of advanced actuation systems. Our plans include testing a smart actuator, an electro-hydrostatic actuator and an electromechanical actuator on the aileron control surface of a NASA F-18 aircraft. Additionally, we have MOAs with the FAA and NASA Langley to explore aging aircraft technology.

The Integration Technology Thrust has a joint program, Innovative Aerodynamic Control, with NASA Dryden that will develop and flight demonstrate the use of thrust vectoring for increasing cruise range and reducing drag during "high g" maneuvers. Emphasis will be placed on using the vectoring nozzle for pitch and yaw trim while moving the aerodynamic controls to a low drag, "in-trail" position.

The Aeromechanics Thrust works closely with the Navy and ARPA to provide affordable performance improvements for future fighter aircraft. Joint efforts are being accomplished with NASA to develop maneuverable extended range configurations for advanced low signature fighters and transports. Rapid aerospace vehicle assessment and optimization codes are being developed, with close collaboration between NASA and Wright Laboratory scientists, to maximize the payoff from each agency's investment. The Aeromechanics Thrust provides technical support to ASC in the application of computational fluid dynamics (CFD) methods for solutions to flight problems encountered by today's operational aircraft. Multibody CFD methods are being developed for certification of stores carriage and release. Aeromechanics programs in nozzle and inlet integration technology are accomplished as a team with the Aero Propulsion and Power Directorate to increase performance, reduce weight and reduce signature.

The Structures Thrust has a joint effort with the Naval Air Warfare Center on smart structures to explore structural health monitoring of Navy and Air Force aircraft and significant improvements to the aircraft structural integrity programs (ASIP and NASIP). A collaborative in-house effort with the Aeromechanics Thrust and Flight Control Thrust is underway to control buffet on twin-tail fighter aircraft at high AOA. Research jointly funded with the FAA is being conducted to account for the effects of corrosion and multiple site damage in structural risk analysis. A cooperative program with NASA Johnson Space Center is underway on deterministic fatigue crack growth analysis. A collaborative program with Phillips Lab and NASA is developing thermal protection systems for reusable launch vehicles. A cooperative program with NASA Langley is testing the transonic dynamics of a 16% model of the F-18 tail. A program is underway with NASA Langley, Georgia Tech and Lockheed on modification and verification of our flagship computer program (ENS3DAE) for analyzing the computational fluid dynamics of aeroelasticity.

The Flight Control Thrust has a joint critical experiment with NASA and the Navy. The objective of the program, Electrically Powered Actuation Design (EPAD), is to flight validate existing designs of electrical actuation devices for the primary control surfaces of high performance aircraft. The Air Force Office of Scientific Research (AFOSR) sponsors the Flight Control Thrust that is researching robust multivariable control theory applied to developing and maturing new design methods and flight control algorithms. AFOSR also sponsors research targeted at developing better aerodynamic modeling techniques to capture highly nonlinear effects.

The Advanced Cockpits Thrust has a joint in-house research program with the Navy, Crew Station Associate Technology (CSAT), that focuses on a capability for parallel, real-time data processing for aircrew decision aids. CSAT will integrate heuristic information processing methods, sensor fusion methods, appropriate processing hardware, and methods of information and software management. The Advanced Cockpits Thrust is coordinated with the Joint Cockpit Office in conjunction with the Armstrong Laboratory Crew Systems Technology Thrust, which includes efforts of Armstrong Laboratory's Human Factors

Engineering Division and Wright Laboratory's System Avionics Division and Advanced Cockpits Branch. A robust and complementary cockpit integration development program has been established between these organizations. Coordination with the Army and Navy on the development of Active Matrix Liquid Crystal Display (AMLCD) and graphical processors is accomplished through direction by the Joint Aeronautical Commanders Group for the Flat Panel Cockpit Display project.

The Vehicle Subsystems Thrust has two MOUs with NASA Langley Research Center (LaRC) on the Radial and Bias Aircraft Tire Testing and the Improved Tire Life programs. NASA LaRC supplies facilities and manpower, and the Air Force supplies hardware, data and manpower. The Vehicle Subsystems Thrust has an MOU with the FAA to conduct research aimed at providing hardening techniques to increase the survivability of transport aircraft. The FAA provides 100% funding, while the Air Force supplies test facilities, manpower, test articles and data. The Vehicle Subsystems Thrust is also working closely with other services and the FAA to explore options for replacing banned ozone depleting substances such as Halon. This Thrust is working closely with Armstrong Laboratory within the technology area of crew escape to expand the performance envelope of ejection systems.

Changes From Last Year

In response to FY95 congressional actions and budget reductions, the following highly user rated programs were terminated or prematurely transitioned: Subsystems Integration Technology, Subsystems Integration and Vehicle Management Technology, Mission Reconfigurable Cockpit, Common Mobility Aircraft Cockpit, Improved Methods for Airlift Cargo Handling, and Fighter Lift and Control.

The Air Vehicles Technology Area – except Advanced Cockpits – is aligned with the DoD Technology Area Plan (DTAP) for air and space vehicles as supported by the Fixed Wing Vehicle Technology Development Approach.

The Air Vehicles Advanced Cockpits Thrust supports the DTAP in Human Systems Interface. The Air and Space Vehicles Technology Area is the integration lead for DoD Fixed Wing Air Vehicles.

The Integration Technology Thrust has formed a new Advanced Concepts core area along with the existing Advanced Development core area. The focus of the Advanced Concepts area is aimed at addressing integration technology issues, i.e., multi-disciplinary design and analysis, and tool development. Application of integration technology shows the best results for technology-driven configurations. This emphasizes integrated solutions to technology issues at the system level during the Research and Development (R&D) phase where they are most cost-effective. The Advanced Development core area conducts near-term flight demonstration programs to validate transitionable technologies for fixed wing air vehicles. The Integration Technology Thrust comprises individuals from the other five thrust areas. This leads to an interdisciplinary S&T approach to subsystem design, analysis and validation. This interdisciplinary approach will provide synergistic benefits through simultaneous integration/involvement of basic disciplines at the notional design phase, and will provide concurrent engineering solutions to multi-disciplinary design problems.

The Flight Dynamics Directorate (FI) has been given the charter to develop a joint aircraft conceptual design standard with ASC/XR. The central focus is on multi-disciplinary designs, and the goal is to develop an integrated design as a conceptual design standard.

FI will ensure linkage between the DTAP and the Technology Development Approach with the Technology Investment Recommendation Report (TIRR) generated by ASC/XR. This linkage becomes the "cycle-deck" for Integration Technologies.

Wright Laboratory has developed a program called Hypersonic Technology (HyTech) at the request of the Deputy Assistant Secretary/Research and Engineering (SAF/AQT). This new program will develop and demonstrate hypersonic technologies that will provide an order-of-magnitude improvement in Air Force weapon system capabilities by the turn of the century. The Flight Dynamics Directorate will develop integration technologies, aeromechanics, structures, controls, and subsystems for a range of potential hypersonic systems (air breathing and rocket-powered, missile and aircraft). Each of the milestones discussed within the Integration Technology Thrust chapter that pertains to the hypersonic technology area are funded from the HyTech PE 0602269F.

THRUST 1: INTEGRATION TECHNOLOGY

User Needs

The Integration Technology Thrust provides technology solutions to a variety of user needs as stated in the MAPs, Mission Need Statements, Operational Requirement Documents and user-proposed Advanced Technology Demonstration programs. Many of these deficiencies have been traceably evolved from operational user needs through strategies-to-task analyses. The users for Integration Technology include Air Combat Command (ACC), Air Mobility Command (AMC), Air Force Special Operations Command (AFSOC), Air Education and Training Command (AETC), Air Force Materiel Command (AFMC), Aeronautical Systems Center (ASC), major System Program Offices, other government agencies such as National Air Intelligence Center, commercial industries and universities.

The programs in this thrust have been derived to solve the following user-documented needs:

- ACC requirements for quick reaction; increased range, maneuverability, and payload; low observable weapon carriage; smart weapon support; controlled-flight departure prevention; enhanced survivability; high AOA simulation testbed; and affordable technologies for the 21st century.
- AMC requirements for improved cockpit commonality, reliability and maintainability, real-time information to aircrews, all-weather intraformation station keeping capability, and all-altitude precision aerial delivery.
- AFSOC requirements for improved thermal energy management systems, night/in-weather covert intraformation collision avoidance.
- AFMC requirements to support the Air Force Test Pilot School and to provide quick reaction support to the major weapon Systems Centers and Logistics Centers in the areas of control hardware and software, aeromechanics, structures, subsystems and cockpit avionics.

Goals

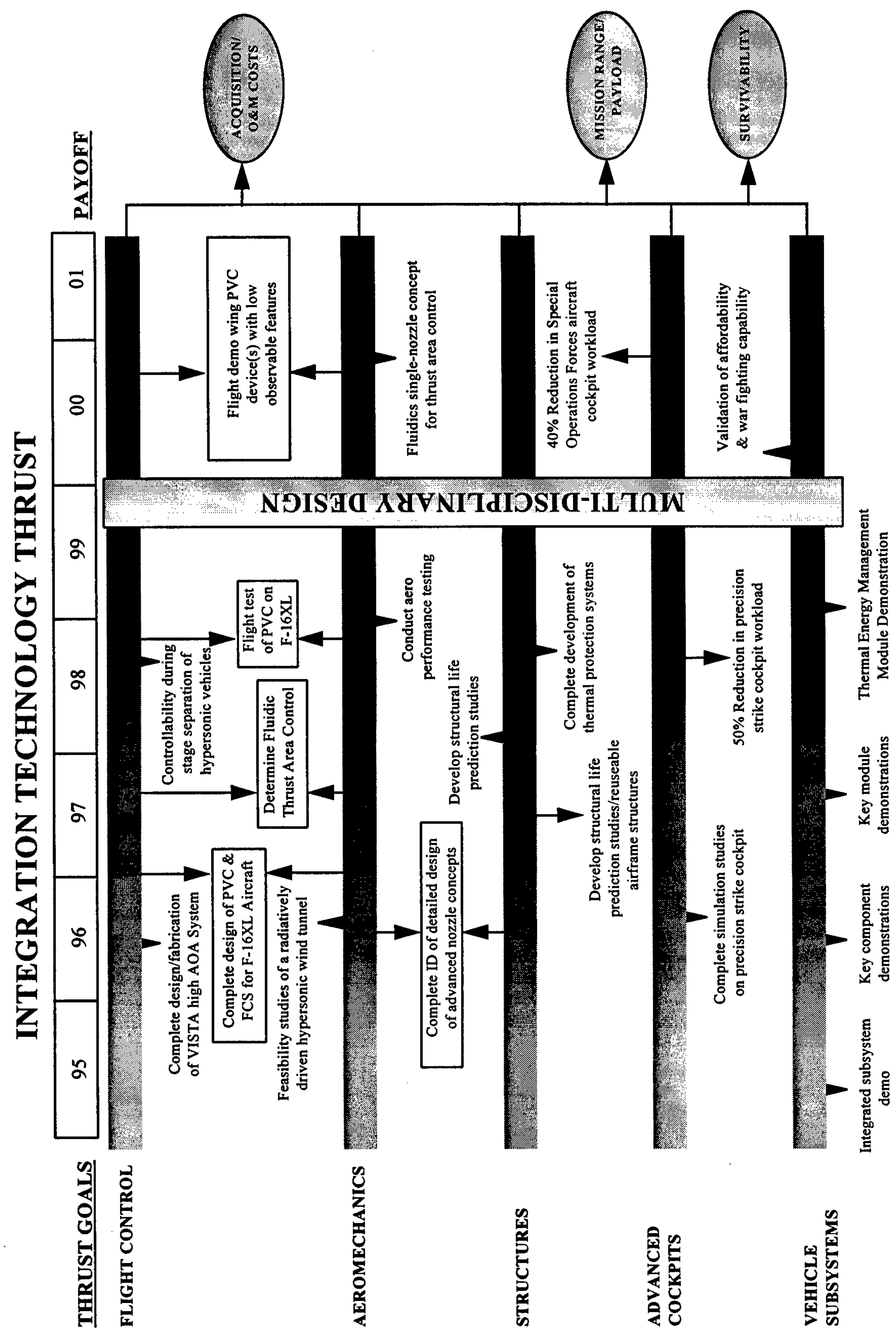
The primary Integration Technology Thrust goals are to identify, mature, and transfer the benefits of advanced multi-disciplinary technologies. The Integration Technology Thrust in concert with Director, Defense Research and Engineering has aligned the following goals to National, Interservice, and Air Force user needs. These goals are grouped in technology areas of Flight Control, Aeromechanics, Structures, Advanced Cockpits, and Vehicle Subsystems (See Figure IT-1). The Integration Technology Thrust will achieve the following goals for a class of baseline air vehicles (F-22, C-17 and SR-71) by the year 2000:

- 20% reduction (RED.) in production costs
- 20% RED. in airframe signature
- 20% increase in lift/drag ratio
- 10% increase in maneuver lift
- 20% RED. in weight (wt.) fraction
- 35% RED. in crew member workload
- 35% increase in reliability
- 25% increase of component service life
- 100% increase in payload fraction
- 10% RED. in wt. penalty for thermal mgmt.

These goals are fully aligned with the DoD Air and Space Vehicles TAP.

Major Accomplishments

- Flight tested forebody chines on the F-16 MATV aircraft to improve lateral directional coupling for enhanced maneuverability at high AOA. Using test results and high fidelity ground-based simulation, developed a method to design forebody flow control design methodology for advanced aircraft applications.
- Completed a preflight qualification 48-hour engine test of an all-envelope, fault-tolerant, axisymmetric thrust vectoring nozzle.
- Nellis AFB OT&E pilots conducted a successful within-visual-range air-to-air combat evaluation of F-16 MATV demonstrating offensive kill capability although outnumbered 2 to 1.
- Accepted the baseline Variable-Stability In-flight Simulator Test Aircraft (VISTA) aircraft with full simulation capability as the Air Force in-flight simulation and research testbed for pre-first flight validation, aeronautical research and test pilot training to reduce advanced aircraft development costs.


INTEGRATION TECHNOLOGY THRUST
THRUST GOALS
PAYOFF
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FLIGHT CONTROL
AEROMECHANICS
STRUCTURES
ADVANCED COCKPITS
VEHICLE SUBSYSTEMS
MULTI-DISCIPLINARY DESIGN
ACQUISITION/ O&M COSTS
MISSION RANGE/ PAYLOAD
SURVIVABILITY
Complete design/fabrication of VISTA high AOA System
Complete design of PVC & FCS for F-16XL Aircraft
Controllability during stage separation of hypersonic vehicles
Flight test of PVC on F-16XL
Flight demo wing PVC device(s) with low observable features
Feasibility studies of a radiatively driven hypersonic wind tunnel
Determine Fluidic Thrust Area Control
Complete ID of detailed design of advanced nozzle concepts
Conduct aero performance testing
Fluidics single-nozzle concept for thrust area control
Develop structural life prediction studies
Develop structural life prediction studies/reuseable airframe structures
Complete development of thermal protection systems
40% Reduction in Special Operations Forces aircraft cockpit workload
Complete simulation studies on precision strike cockpit
50% Reduction in precision strike cockpit workload
Validation of affordability & war fighting capability
Integrated subsystem demo
Key component demonstrations
Key module demonstrations
Thermal Energy Management Module Demonstration

Figure IT-1

• Initiated design of a high AOA system for VISTA (permanent thrust vectoring and programmable display system capability).
• Integrated route planning system for air-to-air surface fighter mission.

Changes from Last Year

The Integration Technology Thrust was also reengineered to incorporate technology-driven notional air vehicles concepts which are incorporated into the Advanced Concepts core area. This core area emphasizes synergistic benefits derived from integrating multidisciplines within its technology base. This integration emphasis spans both near-term (current fleet) and technology-driven future notional air vehicles.

Due to FY95 congressional actions the following highly user rated cooperative technical efforts were canceled and/or prematurally transitioned: Common Mobility Aircraft Cockpit, Air Cargo Handling, Weapons Integration, Mission Reconfigualble Cockpit, Subsytem Integration, and others. Congressional support was given to our VISTA aircraft thrust vectoring upgrade program.

Milestones

The milestones, outlined in Figure IT-1, are grouped in their respective technology goal area. The following milestones further expand the Goals section into specific quantifiable events by fiscal year.

Flight Control

FY96: Complete the design and fabrication of the VISTA high angle-of-attack (AOA) system and programmable display capability. An integrated control software design for expanded envelope (takeoff/landing, air-to-surface, supersonic) operation of the thrust vectored F-15 range enhancement aircraft will also be completed.

FY97: Complete all ground and flight test development of the VISTA high AOA system. Subscale aerodynamic testing of the nozzle concepts to determine fluidic throat area control and fluidic thrust vectoring performance will also be completed. (Research in hypersonic maneuver definitions for the advancement of unmanned research air vehicles will be conducted.*)

FY98: Demonstrate full Initial Operational Capability of the VISTA high AOA system. This will realize a 5% reduction in development cost by providing the Air Force with a unique capability for the simulation and demonstration of high AOA flight operations. Complete flight test of forebody PVC on the F-16XL. Design, fabricate and install advanced maneuverability PVC system on selected flight vehicle testbed. (Ensure controllability during stage separation of multistage hypersonic vehicles.*)

FY00: Flight demonstrate a wing PVC device(s) with low observability features that produce the control moments required by combat aircraft.

Aeromechanics

FY96: Complete design and initiate fabrication of forebody blowing system and digital FCS upgrade of the NASA DFRC F-16XL aircraft. (Continue feasibility studies of a radiatively driven hypersonic wind tunnel.*)

FY97: Complete all-envelope (subsonic / supersonic) "quasi-tailless" flight evaluation on F-15 range enhancement aircraft using the rudder to cancel vertical tail effects. Install forebody Pneumatic Vortex Control (PVC) on the F-16XL and begin flight test. Complete preliminary design of down-selected concept(s) from studies of advanced PVC. (Conduct hypersonic inlet nozzle parametric wind tunnel studies.*)

FY98: Complete all-envelope flight evaluation of reduced (~1/2) tail F-15 ACTIVE, demonstrating the feasibility of thrust vectoring for future directionally unstable, highly maneuverable, tailless fighters for a 5% lift over drag improvement. Integrate advanced nozzle concepts into a 21st century fighter airframe and conduct installed aero performance testing. (Develop and extend aeromechanics and computational techniques from low speed and supersonic flight to the hypersonic environment. Continue feasibility studies and simulations to integrate hypersonic technologies, inlet and nozzle design methodology, reacting gas and shock tunnel tests, and thermal recovery factor in shock/boundary layer interaction for the advancement of unmanned research air vehicles.*)

FY99: Conduct large-scale Radar Cross Section (RCS) testing and data analysis of nozzle/airframe integration concepts to reduce airframe signature. (Coordinate airframe/

propulsion integration for hypersonic flight demonstration.*)

FY00: Prepare for an engine ground demonstration of a single-nozzle concept using fluidics for thrust area control and thrust vectoring.

Structures

FY96: Complete identification and detailed design of advanced nozzle concepts that are low cost, low weight, highly survivable and structurally integrated.

FY97: Develop and continue structural life prediction studies, perform nondestructive evaluation tests and conduct studies of reusable airframe structures.*

FY98: Complete analysis and develop thermal protection systems for structures subjected to critical temperatures.*

FY99: Conduct experimental studies of thermal protection systems for hot structures in hypersonic flights.*

Advanced Cockpits

FY96: Complete simulation studies on single seat air-to-surface precision strike cockpit. Demonstrate 30% reduction in time to visually locate/identify threats in air-to-surface precision strike missions.

FY98: Demonstrate 50% reduction in air-to-surface precision strike cockpit workload.

FY99: Demonstrate inflight route and mission planning capability to achieve 25% decrease in launch reaction time.

FY00: Demonstrate 40% reduction in Special Operations Forces aircraft cockpit workload.

FY01: Develop cockpit concepts for hypervelocity air vehicles.

Vehicle Subsystems

FY95: Initiate an integrated subsystem demo program for the Joint Advanced Strike Technology (JAST) program to validate projected benefits in weapon system affordability/warfighting capability to produce a 4% reduction in weapon system LCC and up to 2,800 lb. reduction in takeoff gross weight.**

FY96: Complete component demonstrations and design of demonstration hardware.**

FY97: Demonstrate key component level modules before fully integrating into subsystem suite.**

FY98: Complete integrated ground based demonstration of an integrated electric power distribution network with electric actuators and flight controls.**

FY99: Complete validation of the affordability and war fighting capability gains from integrated subsystems.** Identify flight control and subsystems requirements for flight demonstration.*

Advanced Concepts

FY96: Complete and validate the Government and Industry Fixed Wing Vehicle (FWV) Technology Development Approach (TDA) representing the Air Vehicles, FWV 15-year plan in terms of goals and objectives in 5-year increments. Establish Integrated Product Teams (IPTs) in the areas of Active Aeroelastic Wing, Maintenance Diagnostics and Close-In Air Combat. Incorporate promising new and emerging technologies into the Air Vehicles strategic plan. Develop concepts and demonstrate a modeling system to compare diverse air vehicle technologies using common metrics.

FY97: Demonstrate and field a modeling system to allow the evaluation of operational benefits of air vehicle technologies in operational and mission environments. Use a modeling system to provide data to rank technology programs. Gain industry involvement in further maturation of modeling system. Conduct feasibility studies, design trades, and simulations to integrate hypersonic technologies into advanced vehicle designs for hypersonic applications.*

FY98: Initiate Advanced Multi-Disciplinary Design (MDD) Validation ground and flight demonstration program (advanced actuator, aeroelastic wing/weapons carriage, adaptive controls, and advanced airframe-mounted fixed geometry vectoring nozzles). Continue evaluation of analytical tools for aero-mechanical, structural, and propulsion flight path dynamics integration using low cost demonstrators.

FY99: Develop optimal analytical tools and integrate technology through MDD. Continue integration of hypersonic technologies to enable advanced designs of high-speed, unmanned research air vehicles.*

FY01: Demonstrate MDD design concepts.

* Funded by HyTech PE 0602269F.
** Funded by JAST PE 0603800F.

THRUST 2: AEROMECHANICS

User Needs

Advanced aeromechanics technologies produce extended range, enhanced maneuverability and increased payload, while enhancing stealth, affordability and maintainability. Substantial gains in military aircraft performance are realized through accurate aerodynamic simulation, efficient low drag air vehicle configurations, and reduced design complexity. Close coordination with the Integration Technology Thrust provides demonstration of revolutionary aerodynamic components to gain recognition for the payoff of technology push programs.

The warfighters' needs addressed in this thrust have been identified in the following Mission Area Plan (MAP) documents and the needs developed in the TPIPT forum:

- Air Combat Command's Counter Air requirements for improved range and maneuverability.
- Air Combat Command's Close Air Support / Interdiction requirements for reducing the range penalty for carrying external stores and developing the technology to provide a standoff fast reaction weapon.
- Air Force Special Operations Command needs for air vehicle technology to support planning for a replacement of aging transport aircraft, to identify new aircraft with VSTOL capabilities, and to develop a hypervelocity munition.
- The Air Combat Command Theater Missile Defense needs for a high-speed interceptor missile.
- Air Force Space Command's Spacelift requirement for a replacement for the Space Shuttle in the next century. A reusable spacelift system is desired.
- Air Force Space Command's Global Deterrence needs for weapon system modernization, including flight vehicles with high maneuverability for extremely accurate targeting.
- Aeronautical System Center (ASC) System Program Offices (SPOs) technology needs for modern day aircraft, such as F-117, B-2, C-17 and technology for emerging concepts, such as JAST.

Goals

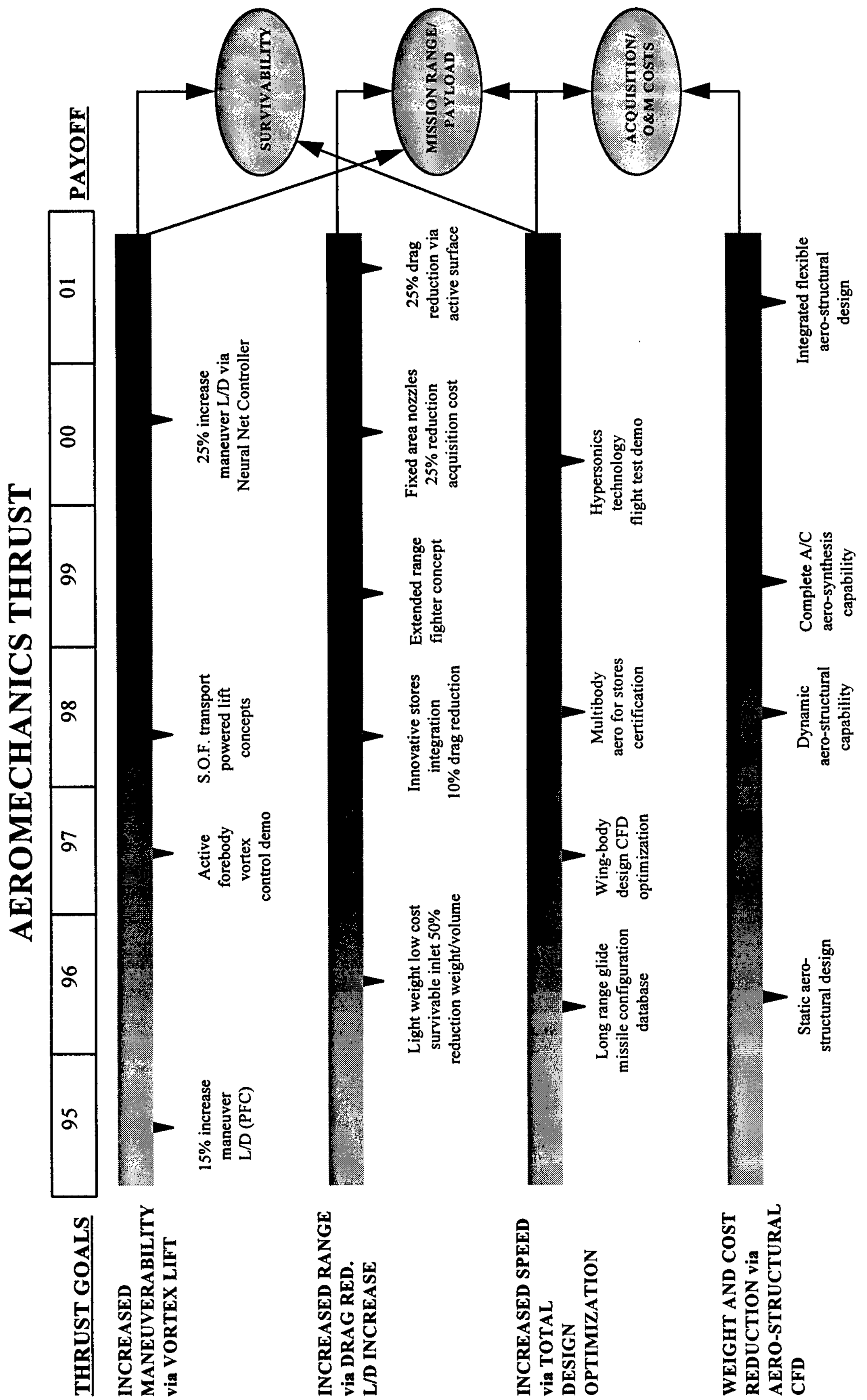
The goals of this thrust are grouped into technology areas of Increased Maneuverability, Increased Range, Increased Speed, and Reduced Weight and Cost (See Figure A-1). The Aeromechanics Thrust will achieve the following goals by the year 2001:

- 10% reduction (RED.) in cruise drag
- 10% increase in maneuvering lift/drag
- 20% increase in low speed lift coef.
- 25% RED. in weapons integration drag
- 30% RED. in weapons integration signature
- 50% RED. in nozzle weight (wt.)
- 30% RED. in nozzle signature
- 50% RED. in inlet duct wt./volume
- 20% RED. in hypersonic turbulent boundary layer heating
- 20% increase in hypersonic inlet performance
- 20% RED. in interference heating area

These goals are fully alligned with the DoD Air and Space Vehicles TAP.

Major Accomplishments

- Demonstrated the successful combination of highly maneuverable flight with low observable configuration features through a cooperative AF-NASA wind tunnel test at the Ames Research Center facilities.
- Significantly reduced the computing cost and turn-around time of computational fluid dynamic (CFD) codes through adaptation to the parallel computing environment.
- Populated the newly acquired aircraft geometry data base with today's operational Air Force aircraft, including the F-22 and the F-117. Availability of the accurate aircraft geometrical descriptions allowed rapid response to requests for analysis of flow patterns about the fuselage of the C-17 and improved performance capabilities of the F-117.
- Successfully completed time-varying airload computations involving the unsteady aeroelastic performance of an F-16 wing and an F-22 tail with wind tunnel tests planned to verify the


AEROMECHANICS THRUST
THRUST GOALS
PAYOFF
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INCREASED MANEUVERABILITY via VORTEX LIFT
15% increase maneuver L/D (PFC)
Active forebody vortex control demo
S.O.F. transport powered lift concepts
25% increase maneuver L/D via Neural Net Controller
INCREASED RANGE via DRAG RED. L/D INCREASE
Light weight low cost survivable inlet 50% reduction weight/volume
Innovative stores integration 10% drag reduction
Extended range fighter concept
Fixed area nozzles 25% reduction acquisition cost
25% drag reduction via active surface
INCREASED SPEED via TOTAL DESIGN OPTIMIZATION
Long range glide missile configuration database
Wing-body design CFD optimization
Multibody aero for stores certification
Hypersonics technology flight test demo
WEIGHT AND COST REDUCTION via AERO-STRUCTURAL CFD
Static aero-structural design
Dynamic aero-structural capability
Complete A/C aero-synthesis capability
Integrated flexible aero-structural design
SURVIVABILITY
MISSION RANGE/ PAYLOAD
ACQUISITION/ O&M COSTS

Figure A-1

accuracy of the results.

- Numerical analysis produced inlet design features for diverterless, offset diffusers to reduce cost, weight, and volume. A cooperative AF-NASA wind tunnel test will validate results in late FY96.
- Advanced high-speed boundary layer transition research significantly with the acquisition of first-ever high quality supersonic experimental measurements of the growth of pressure and velocity disturbances in the boundary layer, which grow to cause transition.
- Conducted benchmark flow field measurements in the Wright Laboratory wind tunnels using the newly developed Doppler Global Velocimeter, enabling 3-D velocity descriptions of a bursting vortex. This simultanious collection of data increases productivity and reduces test time by an order of magnitude relative to the previous Laser Doppler Velocimeter technique.

Changes from Last Year

Aerothermodynamics is no longer identified as a separate sub-thrust. The high-speed technology efforts are combined within the Aerodynamic Configuration Research Subthrust and the Computational Fluid Dynamics Subthrust.

Interdisciplinary computational fluid dynamics, integrating accurate aerodynamic analysis with structural response, received greater emphasis. Cooperative agreements were formed with the Structures Thrust for an integrated aerostructural technology program development.

Milestones

The milestones, outlined in Figure A-1, are grouped in their respective technology goal area. The following milestones further expand the Goals section into specific quantifiable events by fiscal year.

Increased Maneuverability

FY97: Demonstrate fluidics technology for exhaust nozzle thrust vector and throat area control, with a substantial reduction in weight and cost over mechanical devices.

FY98: Complete concept design study for SOF transports, emphasizing low signature, efficient cruise, and short field operation. Wind tunnel data will validate critical performance estimates.

FY00: Develop a boundary layer transition and separation control system using micro-encapsulated machines to regulate the airstream velocity at the wing surface, with machines and sensors connected as a neural net.

Increased Range

FY96: Demonstrate compact inlet and nozzle designs which allow a 5 to 1 reduction in complexity and a 50% reduction in duct weight.

FY98: Achieve a 10% drag reduction for an advanced aircraft, such as the F-22 with external stores, through innovative stores integration.

FY99: Identify affordable extended range fighter configurations featuring advanced control effectors, efficient propulsion integration, and low drag weapons carriage.

FY00: Develop fluidics technology and apply to exhaust nozzles for throat area control and thrust vectoring, eliminating conventional variable geometry devices and controllers.

Increased Speed

FY96: Complete a database for aerothermodynamic characteristics of a high-performance, maneuvering, global-range missile providing validation for flight performance estimates of this type of weapon.

FY97: Achieve wing-body design optimization for a variety of performance objectives, such as range, high lift or low drag, using advanced computational fluid dynamic methods.

FY98: Provide a next-generation CFD tool for stores carriage and separation simulation for use as part of the store certification process.

FY00: Define a hypersonic flight demonstration vehicle for advanced technology development at full-scale conditions where ground test facilities are not available.

Reduced Weight and Cost

FY96: Demonstrate a new aerodynamic/ structural modeling numerical method enabling simulation of static deformation of a wing-body in the design process.

FY98: Demonstrate the integrated solution of structural response to unsteady aerodynamic loads allowing rapid aircraft design for minimum weight.

FY99: Achieve a complete aerospace vehicle synthesis capability for design optimization of manned and unmanned air vehicles that will satisfy multimission tasks.

THRUST 3: STRUCTURES

User Needs

The Structures Thrust supports the Air Force need for higher performance, longer life, and more affordable and survivable aircraft structures. New structural concepts and design techniques will exploit the latest materials and manufacturing technology to produce stronger structures at lower weight and cost, "smart" structures that correct for fatigue and battle damage, and hypersonic structures for extreme environment flight. Mission Area Plan (MAP) needs addressed are:

- The Air Combat Command (ACC) needs improved range, higher readiness, increased performance and survivability, lower buffet vibration, and increased weapons accuracy, all at lower cost.
- The Air Mobility Command (AMC) needs improved field repairs, longer airframe lifetimes, and greater reliability with fewer inspections. AMC also needs improved aircraft economic service life, despite the effects of fatigue and corrosion.
- The Air Force Special Operations Command (AFSOC) needs higher reliability, combat availability, and lower vehicle signatures in short takeoff and landing operations on unprepared landing sites.
- The Air Education and Training Command (AETC) needs much more reliable airframes, with lifetimes as long as 100 years.
- The Air Force Space Command (AFSPC) needs weight-optimized structures for both the replacement space transportation system and for the desired reusable spacelift system.

Goals

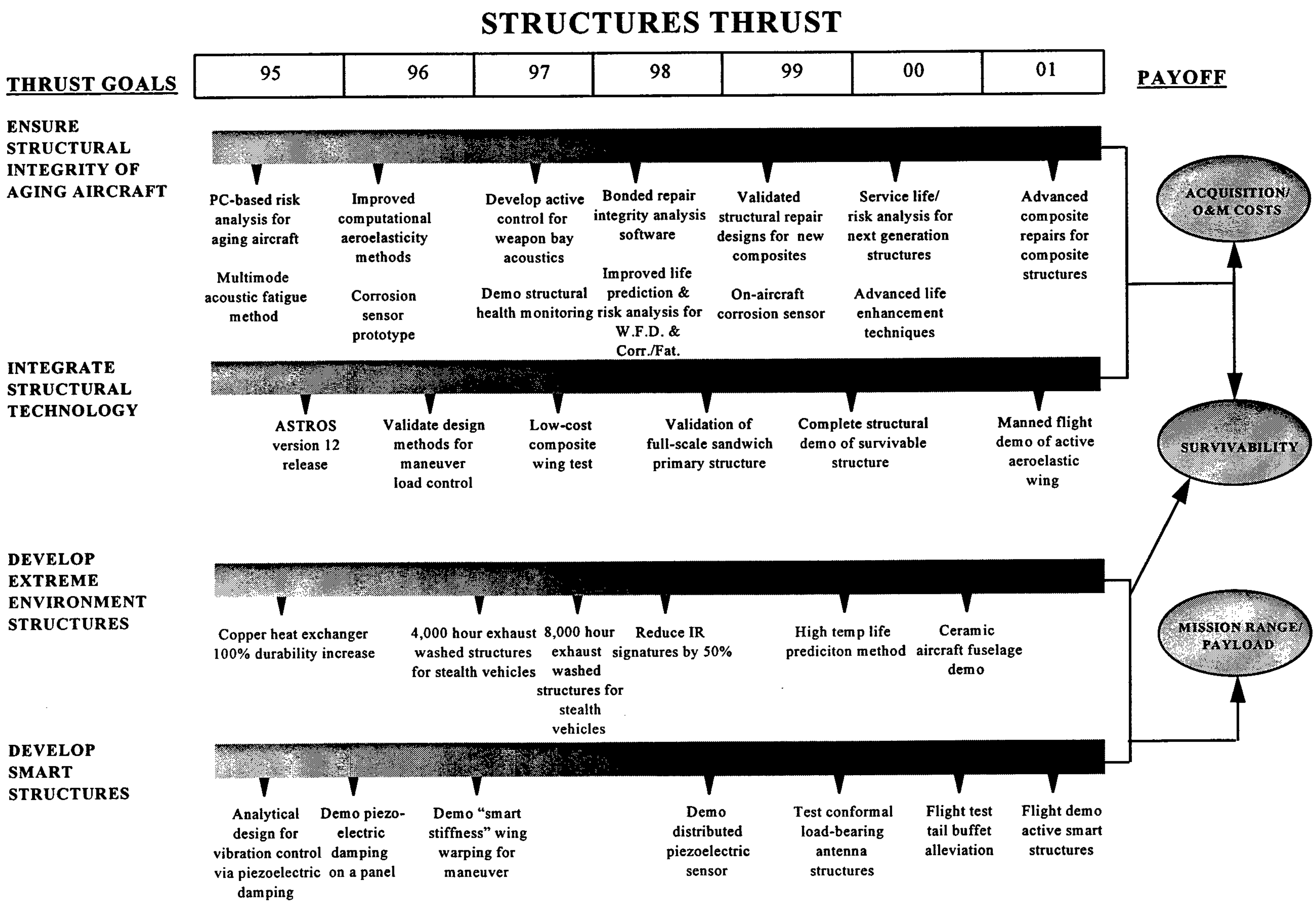
The Structures Thrust goals are grouped into the following technology areas: Ensure Structural Integrity of Aging Aircraft, Integrate Structural Technology, Develop Extreme Environment Structures, and Develop Smart Structures (See Figure S-1). Some of the more specific goals for this Thrust include:

- Reduce AMC aircraft acquisition costs by 25%, and operations and maintenance costs by 30% by the year 2000.
- Improve reliability and combat readiness for ACC aircraft by suppressing vibration and increasing by 20% the engine exhaust impinged structural life for the C-17, B-2 and F-117 by the year 2000.
- Expand the combat capability of ACC aircraft by reducing the structural weight fraction of future fighter aircraft from 30% to 25%, cutting airframe design time in half, and using active aeroelastic wings by the year 2005.
- Reduce AMC operational and maintenance costs by extending the remaining economic lives of the Air Force fleet by 100% by the year 2010.
- Reduce the structural weight fraction of transatmospheric vehicles to 0.1 and develop more affordable, high-speed vehicle structures to enable global range for reconnaissance and strike for ACC and AFSPC by the year 2010.

These goals are fully aligned with the DoD Air and Space Vehicles TAP.

Major Accomplishments

- Completed detail design of a future fighter center fuselage using superplastically formed titanium to demonstrate unitized construction and low-cost tooling.
- Released ASTROS version 11 for improved modeling of deformable aircraft structures, allowing a 40% reduction in preliminary design time.
- Incorporated improved accuracy computer models into crack growth analysis, allowing prediction of structural life in arbitrary stress fields and with residual stresses.
- Generated vulnerability maps for aircraft cargo bays to protect against exploding ordnance and to aid the FAA in protecting commercial aircraft from terrorists.
- Showed feasibility of using smart structures for active alleviation of buffet.
- Demonstrated feasibility of piezoelectric vibration damping of structures in the lab.
- Improved current acoustic load prediction by 50% for Mach 6 vehicles, and experimentally developed sonic fatigue design criteria for carbon/carbon hypersonic structures.


STRUCTURES THRUST
THRUST GOALS
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PAYOFF
ENSURE STRUCTURAL INTEGRITY OF AGING AIRCRAFT
PC-based risk analysis for aging aircraft
Multimode acoustic fatigue method
Improved computational aeroelasticity methods
Corrosion sensor prototype
Develop active control for weapon bay acoustics
Demo structural health monitoring
Bonded repair integrity analysis software
Improved life prediction & risk analysis for W.F.D. & Corr./Fat.
Validated structural repair designs for new composites
On-aircraft corrosion sensor
Service life/ risk analysis for next generation structures
Advanced life enhancement techniques
Advanced composite repairs for composite structures
INTEGRATE STRUCTURAL TECHNOLOGY
ASTROS version 12 release
Validate design methods for maneuver load control
Low-cost composite wing test
Validation of full-scale sandwich primary structure
Complete structural demo of survivable structure
Manned flight demo of active aeroelastic wing
DEVELOP EXTREME ENVIRONMENT STRUCTURES
Copper heat exchanger 100% durability increase
4,000 hour exhaust washed structures for stealth vehicles
8,000 hour exhaust washed structures for stealth vehicles
Reduce IR signatures by 50%
High temp life prediciton method
Ceramic aircraft fuselage demo
DEVELOP SMART STRUCTURES
Analytical design for vibration control via piezoelectric damping
Demo piezo-electric damping on a panel
Demo "smart stiffness" wing warping for maneuver
Demo distributed piezoelectric sensor
Test conformal load-bearing antenna structures
Flight test tail buffet alleviation
Flight demo active smart structures
ACQUISITION/ O&M COSTS
SURVIVABILITY
MISSION RANGE/ PAYLOAD

Figure S-1

• Determined, by wind tunnel tests, the aeroelastic instability boundaries for a single-stage-to-orbit vehicle with highly swept lifting surfaces.

Changes from Last Year

Increased emphasis has been placed on aging aircraft by the DoD and the Air Force. The Wright Laboratory Customer Focus Integrated Product Team (CFIPT) on Aging Systems is directly supported by our Aging Aircraft Subthrust, which is placing increased emphasis on life extension, including the development of corrosion sensing and monitoring systems. This will result in reduced costs of maintaining our aircraft fleets, whose ages in some cases are reaching 50 years or more.

Increased emphasis will be placed on generic hypersonic technology, and on increased cooperation with Phillips Laboratory on thermal protection systems, actively cooled structure, and hot structure for transatmospheric vehicles.

As part of this effort, the Laboratory Space and Launch CFIPT is being supported extensively by our Extreme Environment Structure Subthrust.

Milestones

The milestones, outlined in Figure S-1, are grouped in their respective technology goal area. These milestones further expand the Goals section into more specific quantifiable goals by fiscal year.

Ensure Structural Integrity of Aging Aircraft

FY96: Develop prototype corrosion sensors to reduce the number, cost, and time of inspections for corrosion, and to provide greater reliability. This supports the needs of both AMC and AFSOC.

FY97: Develop an active suppression system for weapons bay acoustics to reduce vibration and increase the envelope and combat effectiveness of ACC aircraft.

FY98: Develop service life/risk analysis to account for the effects of multiple site damage and corrosion fatigue, to provide AMC and AETC with longer-lifetime airframes.

FY00: Develop service life risk analysis for next-generation structures.

FY01: Develop advanced composite repairs for composite structures.

Integrate Structural Technology Into Systems

FY95: Release version 12 of ASTROS, including optimization of bending elements and user-defined constraints.

FY96: Validate multi-disciplinary maneuver load control design methods to reduce gross weight of future ACC fighter aircraft by 10% for improved combat capability.

FY97: Complete static, survivability, and fatigue testing on a full-scale, low-cost, composite-bonded wing.

FY97: Develop structural integrity analysis for bonded repairs to ensure airworthiness for repaired AMC aircraft.

FY98: Complete full-scale validation of sandwich primary structure to support the ACC needs for improved range and payload.

FY01: Perform flight test demonstration of the active aeroelastic wing concept.

Develop Extreme Environment Structures

FY95: Increase the durability of copper heat exchangers for actively cooled engine structure of future hypersonic reconnaissance/strike aircraft by 100% over space shuttle technology.

FY97: Develop 8,000-hour supportable engine exhaust-impinged structure concepts for current and future aircraft.

FY98: Reduce vehicle Infrared (IR) signatures 50% over non-actively cooled designs for extended survivability.

FY99: Demonstrate the 0.1 structural mass fraction required for a military transatmospheric vehicle.

Develop Smart Structures

FY96: Demonstrate "smart stiffness" wing warping for maneuvering without conventional control surfaces.

FY99: Test conformal load-bearing antenna structure to increase stealthiness for improved ACC operational effectiveness.

FY01: Flight demonstrate active smart structures.

THRUST 4: FLIGHT CONTROL

User Needs

The Flight Control Thrust focus is to advance technology in control system design methods and criteria, hardware and mechanization of that hardware, and piloted air vehicle simulation to meet our customers' needs. Technology challenges include increased range, lethality, and survivability, accompanied by decreased costs and supportability requirements.

The customers' needs addressed in this thrust have been identified in the following Mission Area Plan (MAP) documents:

- Air Combat Command's (ACC) Strategic Attack/Air Interdiction MAP calls for increases in reliability while reducing system weight and supportability costs. The Counter Air MAP requires support equipment be minimized to reduce airlift requirements.
- ACC's Theater Missile Defense MAP requires technologies to attack/kill multiple targets on a single pass.
- Special Operations Command's (SOC) Provide Mobility of Forces in Denied Territory MAP requires new long-range, low observable aircraft designed to fight deep in the battlefield.
- ACC's Counter Air MAP requires weapon systems to operate in all environments on the ground and in the air (in all weather).
- Air Mobility Command's (AMC) Airlift MAP calls for electric actuators and fiber-optics for lighter, smaller actuation controls.
- The Technology Investment Recommendation Report (TIRR) identifies SOC, ACC, AMC and Air Education Training Command (AETC) needs for increased range, payload and maneuverability. It states the ability to maintain controlled flight at high AOA is required to improve survivability.
- ACC's Counter Air MAP requires new manufacturing processes to reduce low rate production overhead costs, including advanced control algorithms for manufacturing processes.

Goals

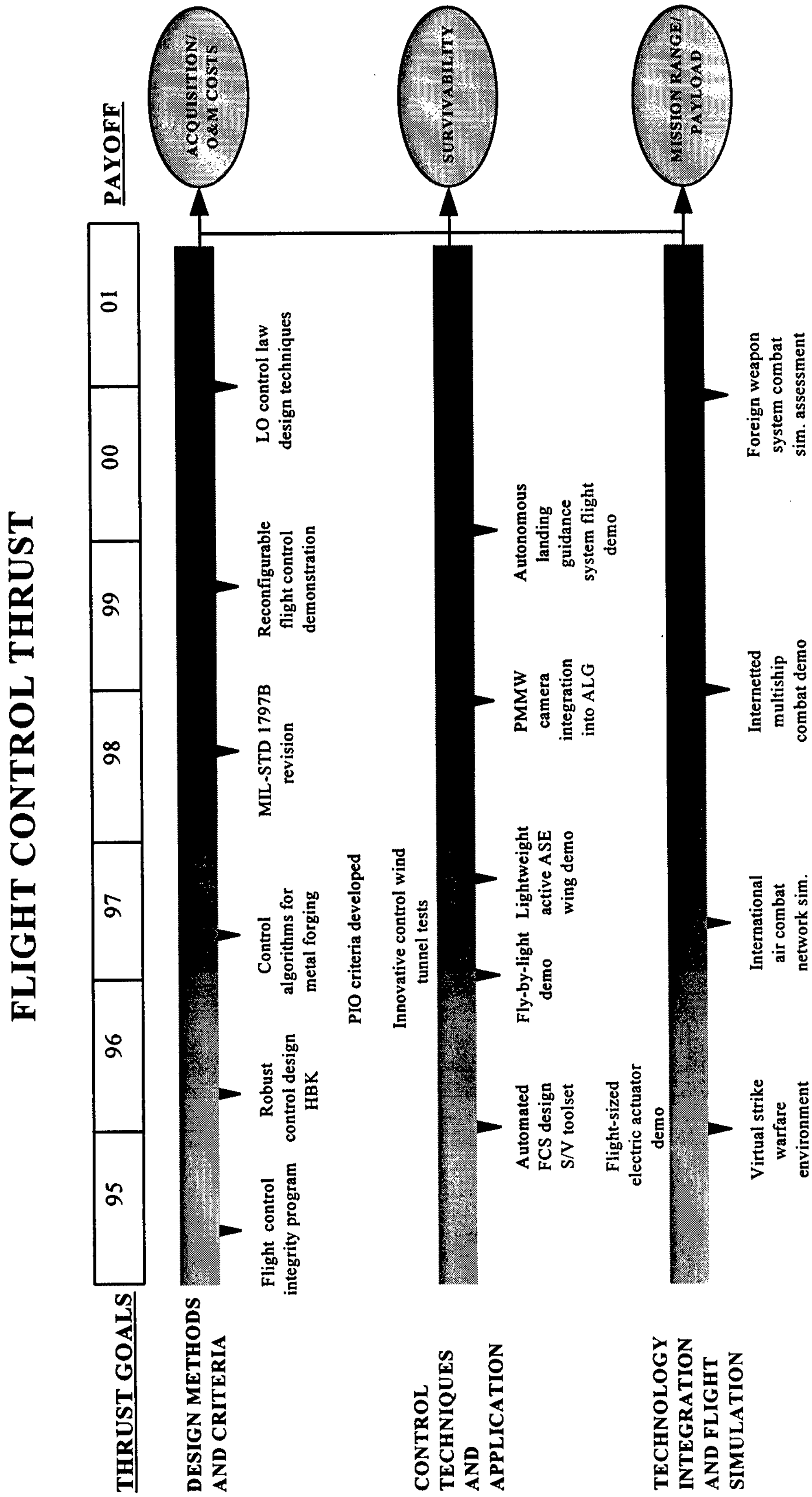
The primary goals of the Flight Control Thrust are to reduce air vehicle design and development costs and to improve combat mission effectiveness. The Flight Control Thrust has aligned the following goals to National, Interservice, and Air Force user needs. These goals are grouped in technology areas of Design Methods and Criteria, Control Techniques and Applications, and Technology Integration and Flight Simulation. The Flight Control Thrust will achieve the following goals for a class of baseline air vehicles (F-22 and C-17) by the year 2000:

- 20% reduction (RED.) in flight control development costs
- 200 pound RED. in flight control hardware
- 70% RED. in low visibility mission aborts
- 15% RED. in drag from lifting and control surfaces
- 50% RED. in cannot duplicate maint. actions
- 70% RED. in control related accidents
- New capability: Electric Actuation

These goals are fully aligned with the DoD Air and Space Vehicles TAP.

Major Accomplishments

- Developed longitudinal reconfiguration control algorithm for battle-damaged aircraft to increase tolerance to combat damage. This supports ACC's need to improve survivability in the emerging air-to-air combat arena.
- Completed update of MIL-STD-1797A Flying Qualities Standard for Fixed Wing Flight Vehicles to incorporate initial pilot-induced oscillation (PIO) criteria and high AOA demonstration maneuvers. This work supports ACC's need for controlled flight at high AOA to increase maneuverability and to reduce development risks and costs.
- Developed optimization algorithm for automated metal forging design tool in cooperation with Materials Directorate, which will aid ACC, AMC, and AFSOC in achieving their goal of lower-cost manufacturing processes.
- Conducted flight test of new electric actuators in F-18 aileron location in joint Air Force, Navy, and NASA program to support AMC's need for lighter, smaller controls through fiber-optics and electric actuation.
- Conducted actuator stiffness testing on the



FLIGHT CONTROL THRUST
THRUST GOALS
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PAYOFF
DESIGN METHODS AND CRITERIA
Flight control integrity program
Robust control design HBK
Control algorithms for metal forging
PIO criteria developed
Innovative control wind tunnel tests
MIL-STD 1797B revision
Reconfigurable flight control demonstration
LO control law design techniques
ACQUISITION/ O&M COSTS
CONTROL TECHNIQUES AND APPLICATION
Automated FCS design S/V toolset
Flight-sized electric actuator demo
Fly-by-light demo
Lightweight active ASE wing demo
PMMW camera integration into ALG
Autonomous landing guidance system flight demo
SURVIVABILITY
TECHNOLOGY INTEGRATION AND FLIGHT SIMULATION
Virtual strike warfare environment sim. demo
International air combat network sim. demo
Internetted multiship combat demo
Foreign weapon system combat sim. assessment
MISSION RANGE/ PAYLOAD

Figure FC-1

YF-22 flaperon and stabilator actuators for the F-22 SPO to reduce F-22 development risk.

- Identified synergistic combination of vehicle management systems, more electric aircraft technologies, thermal power units, and advanced fixed-area nozzles to support ACC's and AMC's need to reduce system weight and support costs.
- Identified candidate vehicle systems diagnostic architectures that support ACC's need to decrease supportability costs by reducing maintenance and repair times, and by reducing support equipment requirements.
- Completed development of precise network simulation timing system to guarantee accurate internetting of national simulation resources and to enable large-scale, high-fidelity, pilot-in-the-loop air combat simulations.

Changes from Last Year

Changes from last year include the transfer of the Advanced Fighter Integration Technology F-16 and In-Flight Simulators from the Flight Control Thrust to the Integration Technology Thrust. Changes also include a slip of one year in the planned completion of the revision of the Flying Qualities Standard and Handbook, MIL-STD-1797, from 1997 to 1998. An additional change includes exploitation of dual-use efforts to accelerate development in electric actuation, fiber-optics and autonomous landing guidance.

Milestones

Design Methods and Criteria

FY96: Complete a robust, multivariable flight control system design handbook to support the low cost design capabilities called for by the TIRR document.

FY97: Complete a new control process to forge advanced metals, greatly reducing costs of low-rate subassembly production, which supports ACC's need to reduce overhead costs.

FY97: Develop PIO criteria to eliminate PIO tendencies in aircraft flight control systems. This objective supports ACC's, AMC's and AFSOC's need to reduce development costs.

FY97: Complete wind tunnel testing and signature evaluation of new low-drag control effectors for future strike aircraft. This technology supports ACC's need to improve survivability.

FY98: Complete revision of Flying Qualities Standard and Handbook, MIL-STD-1797B to support ACC's need for controlled flight at high AOAs to increase survivability.

FY99: Flight demonstrate an advanced aircraft control system capable of reconfiguring itself after detecting battle damage, which supports ACC's need to improve survivability.

FY00: Develop control law design techniques to minimize observability while maximizing performance in support of ACC's and AFSOC's need for greater survivability.

Control Techniques and Applications

FY96: Demonstrate the Ada Software Integrated Development & Verification System to support ACC's need to reduce overhead for low rate production. Both the time and cost of producing and verifying flight-critical software will be substantially reduced.

FY96: Complete development and demonstration of "flight-sized" electric actuator to support ACC's need for reduced mobility airlift requirements by eliminating hydraulic support for flight control.

FY96: Demonstrate an advanced fly-by-light flight control system to support AMC's call for electric actuators and fiber-optics for lighter, smaller actuation controls.

FY97: Demonstrate advanced control algorithms and new actuators for application to the control of lightweight, active aeroelastic wings. This work supports the needs of ACC, AMC, AETC, and AFSOC for greater range, payload and maneuverability.

FY98: Integrate a Passive Millimeter Wave (PMMW) camera for Autonomous Landing Guidance (ALG) application to support ACC's need to operate on the ground and in the air in all environments.

FY99: Flight demonstrate ALG system using PMMW camera. This technology supports ACC's need to operate in all environments.

Technology Integration and Flight Simulation

FY96: Demonstrate a virtual strike warfare combat environment as part of distributed simulation technology development.

FY97: Demonstrate transatlantic, networked simulations with the German M.O.D.

FY99: Complete feasibility simulations of control strategies for multi-ship combat operations in an internetted environment. This work supports ACC's and AFSOC's need to attack/kill multiple targets on a single pass.

THRUST 5: ADVANCED COCKPITS

User Needs

The Advanced Cockpits Thrust provides technology solutions to user needs stated in Mission Area Plans (MAPs), Mission Need Statements, and Operational Requirement Documents of Air Force Operational Commands. Additionally, this thrust addresses requested support from Air Force System Centers, Air Logistic Centers, and other agencies such as ARPA, NASA, the Defense Mapping Agency, NIST, and industry. Its primary goal is to develop, evaluate and integrate effective, affordable cockpit control, display, and decision-aid technologies that reduce acquisition and support costs, enhance mission effectiveness, and increase survivability for current and future aircraft systems to fulfill Air Force operational requirements. The thrust is interdirectorate, comprised of Pilot/Vehicle Interface (PVI) technology and Cockpit Integration in the Flight Dynamics Directorate, and Cockpit Avionics in the Avionics Directorate. The programs are derived to solve these user-documented needs:

- Air Combat Command (ACC): reduced operation and support costs, all-weather operations, real-time information, reduced crew workload, improved situation awareness, rapid mission replanning, laser-hardened cockpit capabilities, helmet-mounted display information, on/offboard sensor information fusion, and improved, reliable multi-function displays.
- Air Mobility Command (AMC): increased reliability and maintainability, reduced crew workload, all-weather operations, improved cockpit avionics integration, improved intraformation positioning information, inflight mission planning and autonomous precision approach/landing capability.
- Air Force Special Operations Command (AFSOC): voice control, advanced displays, improved night vision capabilities, reduced support costs, laser-hardened cockpit capabilities, reduced crew tasking, autonomous precision landing capability, enhanced imagery support, and integrated mission planning.
- Air Education and Training Command (AETC): reduced operation and support costs, advanced display technologies, and support of weapon system training.

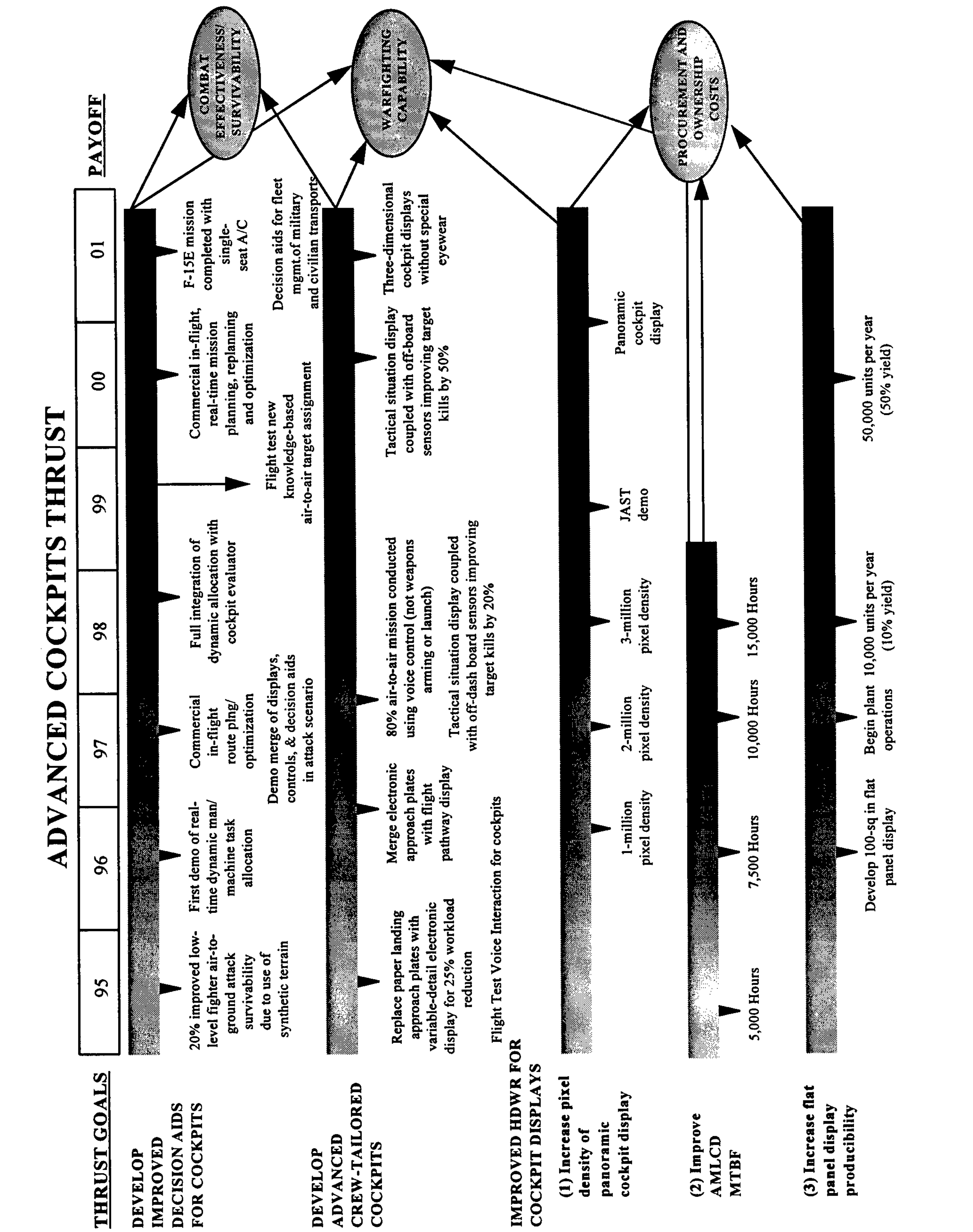
Goals

The Advanced Cockpits Thrust goals support the Human Systems Interface DoD Technology Area Plan (DTAP) and includes:

- Develop innovative PVIs and decision aids that improve situation awareness and reduce crew workload by 60% compared to F-15E type missions by FY 2001.
- Demonstrate, enhanced crew-tailored cockpits for single-seat strike aircraft which lowers weight by 5,000 pounds, compared to the F-15E.
- Develop improved hardware for cockpit displays for form, fit, and function retrofit to existing aircraft and for use in advanced aircraft. These displays must be fully sunlight readable and must enable a 30- to 100-fold mean-time-between-failure (MTBF) improvement over electromechanical and CRT displays used in the F-16, F-15 and F-18.

Major Accomplishments

- Completed C-141 Control-Display System Evaluation that identified flaws in contractor approach and developed recommended improvements to the pilot interface and cockpit tasking, increasing the integration of cockpit information and reducing pilot workload.
- Demonstrated the feasibility of synthetic terrain imaging on helmet displays, increasing all-weather operational capability and improving situational awareness.
- Demonstrated full color red-green-blue (RGB) Solid State Laser Light Source, enabling development of sunlight readable displays.
- Established baseline for innovative application of touch screens, voice, and Hands-On Throttle and Stick (HOTAS) information control methods for target designation on two- and three-dimensional displays, enabling development and application of voice control for workload reduction.
- Established domestic manufacturer of high resolution AMLCDs used for projection display applications.
- Demonstrated high-definition Digital Micro-mirror Device (DMD) projector.
- Established joint work with NASA to perform cockpit voice-control flight tests using


ADVANCED COCKPITS THRUST
THRUST GOALS
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PAYOFF
DEVELOP IMPROVED DECISION AIDS FOR COCKPITS
20% improved low-level fighter air-to-ground attack survivability due to use of synthetic terrain
First demo of real-time dynamic man/machine task allocation
Commercial in-flight route plng/optimization
Full integration of dynamic allocation with cockpit evaluator
Commercial in-flight, real-time mission planning, replanning and optimization
F-15E mission completed with single-seat A/C
Demo merge of displays, controls, & decision aids in attack scenario
Flight test new knowledge-based air-to-air target assignment
Decision aids for fleet mgmt.of military and civilian transports
DEVELOP ADVANCED CREW-TAILORED COCKPITS
Replace paper landing approach plates with variable-detail electronic display for 25% workload reduction
Merge electronic approach plates with flight pathway display
80% air-to-air mission conducted using voice control (not weapons arming or launch)
Tactical situation display coupled with off-dash board sensors improving target kills by 20%
Tactical situation display coupled with off-board sensors improving target kills by 50%
Three-dimensional cockpit displays without special eyewear
Flight Test Voice Interaction for cockpits
IMPROVED HDWR FOR COCKPIT DISPLAYS
(1) Increase pixel density of panoramic cockpit display
1-million pixel density
2-million pixel density
3-million pixel density
JAST demo
Panoramic cockpit display
(2) Improve AMLCD MTBF
5,000 Hours
7,500 Hours
10,000 Hours
15,000 Hours
(3) Increase flat panel display producibility
Develop 100-sq in flat panel display
Begin plant operations
10,000 units per year (10% yield)
50,000 units per year (50% yield)
COMBAT EFFECTIVENESS/ SURVIVABILITY
WARFIGHTING CAPABILITY
PROCUREMENT AND OWNERSHIP COSTS

Figure AC-1

an OV-10B aircraft to test effects of G forces, noise, and oxygen masks on recognition accuracy.

- AMC/CC personally endorsed the inflight mission planner/fleet management cooperative research between Wright Laboratory and Lockheed. The AMC Master Plan now specifically calls for this capability in future upgrades.
- Completed a real-time executive that ensures on-time computer task completion in a dynamic task environment.
- Helped create standard for "Recommended Best Practices for Color AMLCDs in U.S. Military Aircraft."
- Made significant contributions to the National Flat Panel Display Initiative for dual-use application.
- Demonstrated full-color, solid-state lasers for projection displays.

Changes from Last Year

AMC/CC requested that the Advanced Cockpits IPT expand its inflight mission-planning CRDA to include fleet management. The project was refocused accordingly.

The Defense Mapping Agency provided funding and technical support to conduct a study on automating paper-oriented approach and landing maps.

The Advanced Cockpits IPT is supporting Joint Surveillance Target Attack Radar System (Joint STARS) through evaluation of AMLCDs and high-definition projection displays.

Milestones

Improved Cockpit Decision Aids

FY96: Demonstrate dynamic man/machine task allocation to alleviate aircrew tasks, reducing workload of combat missions by 40%.

FY97: Demonstrate inflight route replanning for rapid response to threats, enabling 20% more mission completions and higher survivability.

FY98: Demonstrate dynamic function allocation; integrate with cockpit evaluation system for pilot-in-the-loop part-task testing.

FY99: Demonstrate commercial inflight mission planning capability, integrated with ground-based management systems.

FY01: Demonstrate decision aids, coupled with advanced displays and controls, to enable the F-15E strike mission with a single-seat fighter.

Enhanced Crew-Tailored Cockpits

FY96: Complete software to electronically display variable-detail approach plates for a 25% workload reduction.

FY96: Flight test cockpit voice control to enable hands-off cockpit control during high-workload missions.

FY97: Demonstrate air-to-air mission using cockpit voice control giving the pilot 80% more eyes-up time during combat situations.

FY97: Demonstrate multitarget, multikill capability of "pathways" symbology.

FY98: Demonstrate tactical situation display with fused sensor information, increasing single-pass target kills by 25%.

FY99: Demonstrate PVI suite for next generation SOF aircraft, reducing mission crew by one over current aircraft.

FY00: Improve integration of tactical situation displays, symbology, and information fusion to increase target kills by 50%.

FY01: Achieve 40% improvement in situational awareness with 3-D displays that do not require special eyeware. This will enable no-canopy embedded cockpits and full laser protection.

Improved Hardware for Cockpit Displays

Cost-effective hardware is needed to meet requirements for improved situational awareness.

1) <u>Increased Pixel Density Panoramic Displays</u>
FY96: Demonstrate 1-million pixel color laser projection display for use in Joint STARS.
FY98: Achieve 3 million pixel density.
FY99: Give JAST demonstration of 3-million pixel panoramic display.
FY01: Demonstrate fully panoramic cockpit display for no-canopy embedded cockpits.

2) <u>Improved AMLCD MTBF</u>
FY96: Demonstrate large, affordable AMLCDs with 7,500 hours MTBF.
FY97: Demonstrate two-fold increase in optical efficiency and 10,000 hours MTBF.
FY98: Achieve 15,000 hours MTBF.

3) <u>Increased Flat-Panel Display Producibility</u>
FY96: Develop 100-sq in flat-panel display.
FY97: Begin U.S. plant operations.
FY00: Produce 50,000 units per year, 50% quality production yield.

THRUST 6: VEHICLE SUBSYSTEMS

User Needs

The Vehicle Subsystems Thrust focuses on technology developments to decrease aircraft weight, increase mission range, reduce cost of ownership, and enhance survivability and safety, thus increasing warfighting capability. We act as catalysts to transition our technology outside DoD applications. This thrust develops technologies that address many of the subsystems issues associated with an air vehicle. These technologies include transparency systems, tires, wheels, brakes, landing gear struts, fire suppression, combat damage reduction, ground turnaround, escape systems, thermal management, and component integrity.

The following requirements have been extracted from Mission Area Plans (MAPs), Technology Planning Integrated Product Team (TPIPT) documentation and other sources of requirements information through the Wright Laboratory Product Technology Plan.

AIR MOBILITY COMMAND

- Birdstrike resistant transparencies.
- Better battle damage repair concepts.
- Lighter/stronger airframe components.
- Cost effective weapon system availability.

AIR COMBAT COMMAND

- Reduced manufacturing costs.
- Improved reliability, maintainability, and supportability built into all components (Counter Air MAP).
- Lighter/stronger airframe components, easily repaired on the flightline.
- Enhanced battle damage repair concepts.
- Increased number of landings per F-16 tire (Counter Air TPIPT).
- Increased subsystem reliability (Air-to-Surface TPIPT).
- Need for maintenance diagnostics (Counter Air and Air-to-Surface TPIPTs).
- Classified upgrade requirements (ACC Strategic Attack/Air Interdiction MAP).

AIR EDUCATION & TRAINING COMMAND

- New T-38 birdstrike resistant transparency with through-the-canopy ejection.

AIR FORCE SPECIAL OPERATIONS COMMAND

- Improved air drop accuracy.
- Improved environmental control system.
- Reduced aircraft weight and drag.

Goals

The Vehicle Subsystems goals are grouped in technology areas of Acquisition and Support Cost Reduction, Landing Gear Systems, Fire Suppression and Combat Damage Reduction / Repair, Aircrew Safety, and Thermal Management. The goals listed below are targeted toward F-15, F-16, and F-22 class aircraft and will be accomplished by FY01.

- Eliminate 1,000-lb subsystems weight.
- Provide 700 knots airspeed safe ejection.
- Validate 50 landings per tire for fighters.
- Save $20M/year from windshield system.
- Improve efficiency of onboard fire extinguisher.
- Increase avionics cooling and reduce IR signature.
- Improve weapons bay survivability for a ballistic impact munition.

These goals are fully aligned with the DoD Air and Space Vehicles TAP.

Major Accomplishments

- Identified a replacement for Halon for dry-bay and engine nacelle applications.
- Demonstrated a science-based, dry-bay fire prediction model.
- Demonstrated field battle damage repair kit for multicontoured surfaces.
- Transitioned antistatic environmental protection coatings for operational evaluation.
- Completed Halon Replacement candidate agent screening and down-selected to one agent.
- Developed initial improved tire for Block 50 F-16.
- Completed preliminary design of F-18 TMC drag brace piston.
- Completed detail design of F-16 electric actuated brake.

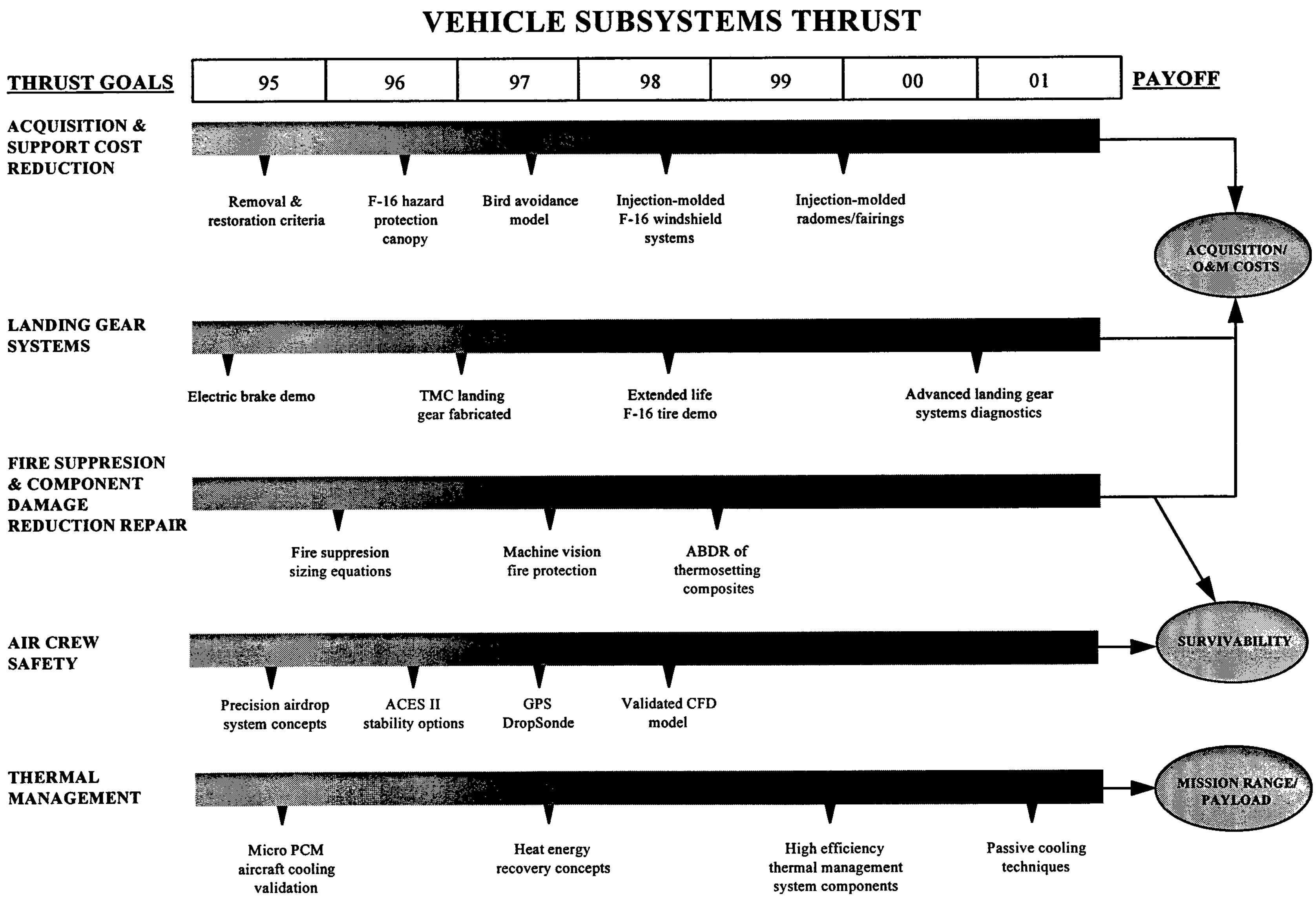
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Figure VS-1

- Developed options for reducing B-1B windshield system cost.
- Demonstrated wind profile measurement proof-of-concept.
- Validated birdstrike-resistant F-22 canopy design.
- Validated concepts for ACES-II ejection seat stability.
- Identified weapons bay survivability concepts for a ballistic impact munition.

Changes from Last Year

A new effort, Subsystems Integrated Design Assessment Technology (SIDAT), will be started.

The restrictions on the funding profile for the Extended Life Tire (EXLITE) effort will delay the final demonstration from FY97 to FY98.

Milestones

The milestones, outlined in Figure VS-1, are grouped in their respective technology goal area. These milestones further expand the Goals section into more specific quantifiable events by fiscal year.

Acquisition and Support Cost Reduction

FY96: Define system requirements for injection molded frameless next-generation transparency.

FY96: Demonstrate low-cost B-1B windshield.

FY96: Demonstrate process/criteria for restoring the F-15 transparency optical quality.

FY97: Validate bird avoidance model.

FY97: Demonstrate F-16 transparency laser protection coating.

FY97: Deliver removal/restoration criteria for transparencies.

FY98: Produce an injection molded canopy for the F-16.

FY98: Demonstrate bio- and aero-sciences to reduce birdstrikes by 20%.

FY00: Demonstrate injection model radomes and fairings.

Landing Gear Systems

FY96: Fabricate a titanium matrix composite drag brace piston with 50% weight savings.

FY97: Bring on-line, full-scale tire wear test capability.

FY98: Demonstrate an F-16 tire with double the number of landings of current tires.

FY00: Demonstrate concept for advanced landing gear systems diagnostics.

Fire Suppression and Combat Damage Reduction/Repair

FY96: Validate dry-bay, extinguishing-sizing equations for Halon replacement agents.

FY96: Demonstrate machine-vision, fire protection system for dry bays and weapons bays.

FY96: Evaluate candidates for low observable battle damage repair.

FY96: Evaluate repair concepts for battle damage repair of thermosetting composite materials.

FY97: Demonstrate weapons-bay survivability from a ballistic impact munition.

Aircrew Safety

FY96: Deploy a prototype of the GPS DropSonde to improve precision air drop.

FY96: Fabricate a titanium matrix composite drag brace piston with 50% weight savings.

FY96: Demonstrate ACES II stability options for safe ejection.

FY97: Validate a GPS DropSonde for improved precision air drop.

FY98: Validate computational fluid dynamics model for 700 KEAS safe ejection.

Thermal Management

FY96: Demonstrate heat transfer enhancement techniques.

FY97: Demonstrate the efficient and catalytically enhanced conversion of waste heat to useful work.

FY99: Validate high-efficiency thermal energy management system components.

FY01: Demonstrate passive cooling techniques as an alternative design for aircraft thermal management.

FY01: Demonstrate high intensity heat-transfer techniques to effectively miniaturize heat exchangers.

GLOSSARY

ACC	Air Combat Command
ABDR	Aircraft Battle Damage Repair
ACTIVE	Advanced Controls Technology for Integrated Vehicles
AETC	Air Education Training Command
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
ALG	Autonomous Landing Guidance
AMC	Air Mobility Command
AMLCD	Active Matrix Liquid Crystal Display
AOA	Angle-of-Attack
ARPA	Advanced Research Projects Agency
ASC	Aeronautical Systems Center
ASIP	Airframe Structural Integrity Program
ASSET	Aerothermodynamics/Elastic Structural Systems Environmental Tests
BES	Budget Estimate Submission
CFD	Computational Fluid Dynamics
CFIPT	Customer Focus Integrated Product Team
CRDA	Cooperative Research & Development Agreement
CRT	Cathode Ray Tube
CSAT	Crew System Associate Technology
CTC	Center Technology Council
DDR&E	Director, Defense Research & Engineering
DEA	Data Exchange Agreement
DMD	Digital Micromirror Device
DoD	Department of Defense
DTAP	DoD Technology Area Plan
EPAD	Electrically Powered Actuation Design
EXLITE	Extended Life Tire
FAA	Federal Aviation Agency
FI	Flight Dynamics Directorate
FWV	Fixed Wing Vehicle
FY	Fiscal Year
GPS	Global Positioning System
HOTAS	Hands-On Throttle and Stick
HQ	Headquarters
IEA	Information Exchange Agreement
IPT	Integrated Product Team
IR	Infrared
JAST	Joint Advanced Strike Technology
KEAS	Knots Equivalent Airspeed
LaRC	Langley Research Center
LCC	Life Cycle Costs
LO	Low Observable
MAJCOM	Major Command
MAP	Mission Area Plan
MATV	Multi-Axis Thrust Vectoring
MDD	Multi-Disciplinary Design
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MTBF	Mean-time-between-failures
NASA	National Aeronautics & Space Administration
NASA DFRC	NASA Dryden Flight Research Center
NASIP	Navy Airframe Structural Integrity Program
NIST	National Institute of Standards & Technology
OT&E	Operational Test & Evaluation
PIO	Pilot Induced Oscillation
PMMW	Passive Millimeter Wave
POM	Program Objective Memorandum
PVC	Pneumatic Vortex Control
PVI	Pilot/Vehicle Interface
RCS	Radar Cross Section

GLOSSARY (Continued)

R&D	Research and Development
RDT&E	Research Development Test & Evaluation
RGB	Red-Green-Blue
S&T	Science & Technology
SIDAT	Subsystems Integrated Design Assessment Technology
SOC	Special Operations Command
SOF	Special Operations Forces
SPO	System Program Office
STARS	Surveillance and Target Acquisition Radar System
TAP	Technology Area Plan
TAV	Transatmospheric Vehicle
TDA	Technology Development Approach
TEO	Technology Executive Officer
TIRR	Technology Investment Recommendation Report
TMC	Titanium Matrix Composite
TMP	Technology Master Plan
TPIPT	Technology Planning Integrated Product Team
TTO	Technology Transition Office
VISTA	Variable-Stability In-Flight Simulator Test Aircraft
WL	Wright Laboratory
WVR	Within Visual Range

TECHNOLOGY MASTER PROCESS OVERVIEW

Part of the Air Force Materiel Command's (AFMC) mission deals with maintaining technological superiority for the U.S. Air Force by:

- Discovering and developing leading-edge technologies.
- Transitioning mature technologies to system developers and maintainers.
- Inserting fully developed technologies into our weapon systems and supporting infrastructure.
- Transferring dual-use technologies to improve economic competitiveness.

To ensure this mission is effectively accomplished in a disciplined, structured manner, AFMC has implemented the Technology Master Process (TMP). The TMP is AFMC's vehicle for planning and executing an end-to-end technology program on an annual basis.

The TMP has four distinct phases, as shown in Figure 1:

- Phase 1, Technology Needs Identification–Collects customer-provided technology needs associated with both weapon systems/product groups (via TPIPTs) and supporting infrastructure (via CTCs), prioritizes those needs, and categorizes them according to the need to develop new technology or apply/insert emerging or existing technology. Weapon system-related needs are derived in a strategies-to-task framework via the user-driven Mission Area Planning process.
- Phase 2, Program Development–Formulates a portfolio of dollar-constrained projects to meet customer-identified needs from Phase 1. The Technology Executive Officer (TEO), with the laboratories, develops a set of projects for those needs requiring development of new technology, while the Technology Transition Office (TTO) orchestrates development of a project portfolio for those needs which can be met by the application/insertion of emerging or existing technology.

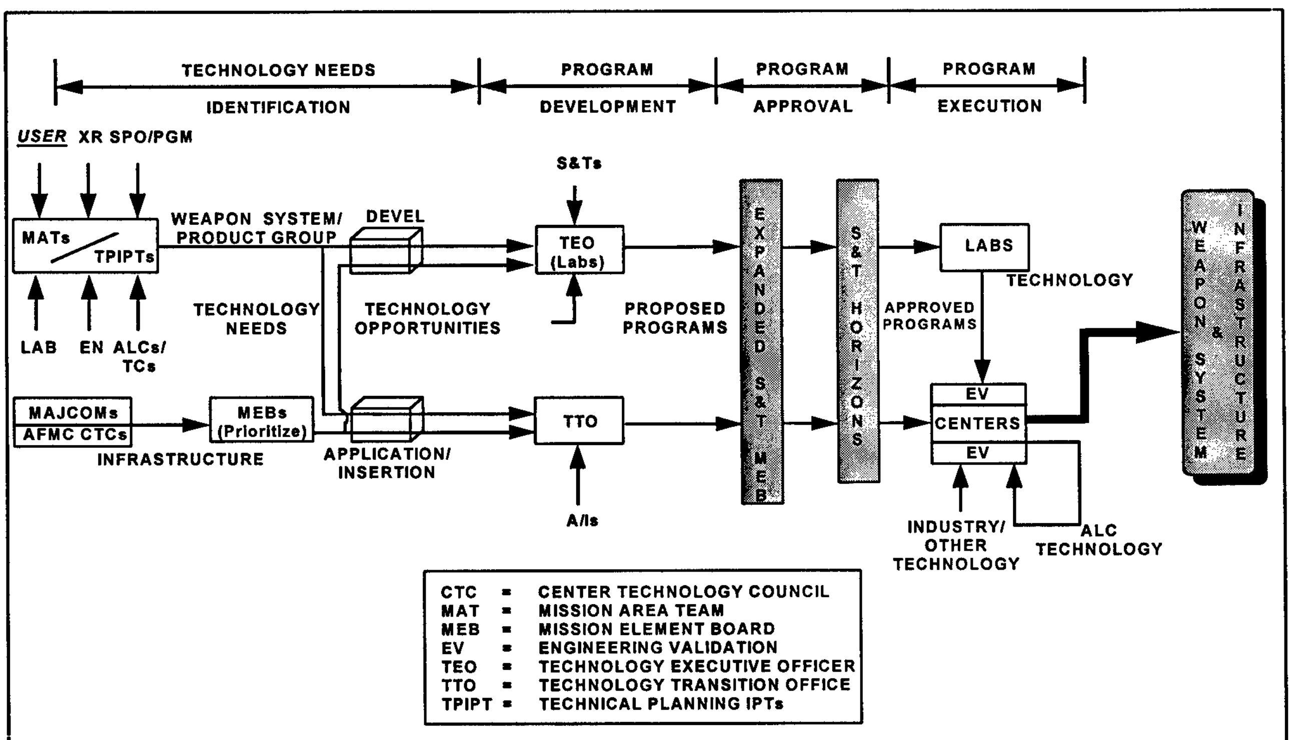

Figure 1 - Technology Master Process

- Phase 3, Program Approval–Reviews the proposed project portfolio with the customer base via an Expanded S&T Mission Element Board and, later, the AFMC Corporate Board via S&T HORIZONs. The primary products of Phase 3 are recommended submissions to the Program Objective Memorandum/Budget Estimate Submission for the S&T budget and for the various technology application/insertion program budgets.

- Phase 4, Program Execution–Executes the approved S&T program and technology application/insertion program within the constraints of the Congressional budget and budget direction from higher headquarters. The products of Phase 4 are validated technologies that satisfy customer weapon system and infrastructure deficiencies.

TMP Implementation Status

The TMP is in its first full year of implementation. AFMC formally initiated this process at the beginning of FY94, following a detailed process development phase. During the FY95 cycle, AFMC will use the TMP to guide the selection of specific technology projects to be included in the Science and Technology FY98 POM and related President's Budgets.

Additional Information

Additional information on the Technology Master Process is available from HQ AFMC/STP, DSN 787-7850; (513) 257-7850.

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INTERNET DOCUMENT INFORMATION FORM

A . Report Title: FY96 Air Vehicles Technology Area Plan

B. DATE Report Downloaded From the Internet 10/2/98

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #): **Headquarters AF Material Command**
Directorate of Science & Technology
Wright Patterson AFB, OH 45433

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: VM_ **Preparation Date**: 10/07/98__

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.